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SAMPLING DUST IN ROCK-DUSTED MINES [1]

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When explosions have occurred in mines where rock dust has been used to some extent, generally to a very limited extent, the press has immediately characterized those mines as "rock-dusted." To persons familiar with the method of rock-dusting, it is apparent that if rock-dusting is done properly, if all mine surfaces are rock-dusted to within at least 40 feet of the faces of rooms and entries, and if the incombustible content of the dust is more than 65 per cent, there is little likelihood that an explosion of coal-dust will occur. The report that an explosion has occurred in a "rock-dusted" mine immediately conveys to the mind of the alert safety advocate the information that the mine is inadequately rock-dusted or that either dust sampling of the rock-dusted surfaces has not been done or, if done, the mine has not been redusted with sufficient promptness.

Rules for Collection of Samples

Collection of dust samples is by no means intricate, but a few simple rules must be kept in mind if the results are to be dependable. A sample must represent the true average conditions of the dust in the section or zone in which it is taken, and therefore the point at which the sample is to be collected must be selected with care. During an explosion much if not all of the dust on the ribs, roof, timber, and road in the affected region is blown into the air; the sample, therefore, should contain all loose dust and material on the surfaces to a depth of about 1 inch, if that amount is present. If there is considerable sand locally along the track, care must be taken not to include enough of this material to vitiate the sample and distort the results; however, if the sand is distributed throughout the region being sampled it should be included. Dust should not be collected from recesses in the ribs, such as hitches cut for timber, as the character of the dust in such places is often different from that on the ribs proper. Samples should not be collected at points where the dusting machine has been loaded, or at a point where the machine has stopped and discharged for a longer period than at other points on the entry or in the rooms. In short, the sample must represent AVERAGE CONDITIONS, and if there is any doubt as to the character of the dust it is far better to have too much combustible matter than too much incombustible matter in the sample, as it is best to err on the side of safety if it is necessary to err.

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Sampling Stations

To insure that the mine is well sampled, it may be advisable to divide it into sections or sampling zones. Such zones may be divided into sections 500 feet long with a station appropriately marked at 500-foot intervals; in any event the sampling stations should not be more than 1,000 feet apart. A sample, representative of average conditions, should be collected in each such zone about once a month.

Frequently samples of dust are collected on the haulage roads only and nowhere else; it is important that samples be collected on all entries, on all air courses, and in rooms that are rock-dusted. It is advisable in collecting samples to take them at points approximately opposite on all entries in a set; this is important. In a mine where a recent disastrous explosion took place some of the haulage roads were coated with rock-dust, but in these sections the explosion was propagated along the adjacent untreated entries. Even if the trackless entries are rock-dusted, there is a tendency to disregard all but haulage roads when samples are taken. If, whenever a sample is collected from the haulage road, samples are also taken from the adjoining parallel entry or entries at a point or points approximately opposite the place of taking the haulage entry sample, a definite check is obtained on the dust conditions at that part of the mine. As the trackless entries do not have much dust carried into them, experience may show that sampling once every three months may be frequent enough. On the other hand, the return air course in sections where mechanical loading machines are operated running dry, there is likely to be much finely divided settled dust and there is frequently need of sampling every two weeks. As an example, a sample of road dust was collected 55 feet outby the face of an entry in which the coal was loaded mechanically, about a week after the entry (trackless and on the return air) had been rock-dusted. The coal-dust had settled thickly on the floor but when this black covering was brushed away, a layer of rock-dust more than a quarter of an inch thick was found beneath; when the sample was analyzed, the incombustible content was found to be but 56 per cent. Therefore particular attention should be given to such special conditions, and samples should be collected as often as necessary.

Kind of samples to collect

For regular mine sampling there are two kinds of dust samples: the rib and roof sample and the road sample. There is often not enough dust on the roof to make a sample for testing, so that the rib and roof dust is usually combined in one sample. The road dust should be sampled at the same point where the rib and roof dust is collected and the two samples should be kept separate. If there is much timber in a room or entry, a sample should also be taken by brushing all of the dust from the post and crossbar (if this system of timbering is employed).

It is important that the timber dust be sampled, for the dust floating in the air settles on the top and sides of crossbars and on the sides of posts. The float dust is extremely finely divided, hence is the most explosive size of coal-dust found in mines. The dust settling on the roof and ribs is often fine, ranging from 20 to 40 or more per cent through a 200-mesh sieve; of all mine dusts

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this is the most easily raised into a cloud in an explosion, therefore knowledge of its quantity and composition is essential in coal-dust explosion prevention methods.

The dust on the floor is, as a rule, coarser than that on the ribs and roof; it is also mixed with larger pieces of coal and rock; the finer dust is caused to work toward the bottom of the accumulation of coal and waste material by the vibration from the traffic on haulage roads. In the average mine there is at least ten times as much dust on the floor as on the ribs and roof. Consequently, in order to be able to judge accurately the condition of rock-dusting, the road-dust sample should be kept separate from the rib and roof dust sample; this is an important point very generally missed in dust sampling as to ascertain explosibility conditions. It has been observed that many men in collecting peripheral samples, including dust from roof, ribs, and floor, take only the surface of the road dust, hence are likely to fail to include much material likely to participate in an explosion should one occur; moreover, there are numerous other discrepancies resulting from this type of sampling.

The following table compares the percentages of dry incombustible in dust samples collected from ribs and roof and road with samples collected from the entire periphery.

Table 1.- Comparison of standard Bureau of Mines method of sampling dust with peripheral method of sampling

Samples	Dry incombustible, per cent				
	Test 1	Test 2	Test 3	Test 4	Test 4
Rib and roof dust sample .	93	96	95	92	87
Road dust sample	32	82	67	49	34
Unweighted average	62	89	81	71	61
Peripheral sample	43	74	62	50	33

The unweighted average shows the average of the rib, roof, and road dust samples, if the same weight of material were collected in each sample. This is not the true average but would be the average if the peripheral sample were taken to an equal depth from the ribs, roof, and road. In test 1 the road dust contains about a third as much incombustible matter as the rib and roof dust sample, and the unweighted average is 62 per cent; however, the peripheral sample contains 43 per cent, showing that more road dust than rib and roof dust has been collected. Actually, the sampler collected a thin coating from the road, so that the incombustible matter approaches the unweighted average more closely than any other peripheral sample. Even though a thin coating was collected from the rib, the excessive amount of road dust affects the sample. The average dust sample from the ribs and roof weighs 50 to 100 grams, whereas the dust from the road weighs from 500 to 1,500 grams; the effect of such large quantities of road dust on the peripheral samples is shown in tests 2 to 4 inclusive. The larger percentage of incombustible matter in the road dust than in the peripheral samples in tests 2

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and 4 is probably due to the fact that the two samples were taken adjacent to each other, and a slight difference in the composition of the dust is to be expected. In all of the other peripheral samples the incombustible content is approximately the same as in the road-dust samples. In the above illustrations the combustile content is high in the road dust; hence, from the results of the peripheral samples, redusting would undoubtedly be done immediately, yet on the other hand if the entry were little used and the road dust were high in non-combustible material, the ribs might be sufficiently combustible to propagate an explosion. Therefore, it is readily seen that a peripheral sample does not give a true indication of the effectiveness of rock-dust in rendering inert the coal-dust on all surfaces of an entry or room, and to obtain the true perspective of the effectiveness of the rock-dusting the road dust must be sampled separately from the rib and roof or the timber. Test data, which have not been confirmed, appear to indicate that less inert matter is required in road dust than in rib and roof dust to prevent propagation of an explosion. If this is the case, peripheral samples can not truly indicate the need of redusting.

In a study of the explosibility of coal-dust, H. P. Greenwald says on page 20 of Technical Paper 386, "Explosibility of coal-dust from four mines in Utah": "When there is a strip of more or less pure coal dust on the floor in the center of the entry (as from spillage) this strip must receive special consideration. Well rock-dusted ribs will not take care of it, and unless rock-dust can b placed on overhead timbers or projections extending entirely across the entry, th center strip must be treated separately." It is therefore important to know the composition of the road dust, and this is accomplished by taking road dust sample separately from the rib and roof dust.

How to collect dust samples

Having selected a point that appears to be representative of the dust conditions in a zone, the samples is collected as follows:

All of the loose dust to a depth of 1 inch is taken in a strip 6 inches wide on the floor from rib to rib. The material is screened through a 10-mesh sieve, and if there is more dust than the container will hold, the sample is plac on an oilcloth and the dust is mixed thoroughly. The best method of mixing is to roll the dust from end to end of the oilcloth or canvas alternately, taking care that the dust does not slide instead of rolling. This is done by grasping the lower right-hand corner and the upper left-hand corner on the right side and the left side of the oil cloth or canvas, then rolling the dust from the right to the left and from left to right; with the fingers under the cloth, the right hand is slid to the upper right corner and the left hand to the lower left corner and the rolling is repeated; the above process is repeated until the dust is thoroughly mixed. The sample is then coned and quartered until all the remaining dust can be placed in the sample container, which in Bureau of Mines work is a galvanized iron can with screw cover that can readily be made approximately air-tight.

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The rib and roof dust sample is collected by taking all of the dust (unless more than 1 inch thick) from oneor more strips 6 inches wide on the roof and ribs; generally several 6 inch strips must be sampled, and it is important that the approximate area sampled should be recorded. As the finest dust is generally found on the ribs and roof, the greatest care should be taken to prevent the fine dust from being dislodged and blown away by the air current. Holding a piece of brattice cloth or a coat between the moving air currents and the collector reduces the loss. This precaution should be taken especially when collecting dust from timber.

Types of Sampling Equipment

The Bureau of Mines uses the "scoop-and-brush" method of collecting dust samples. A metal scoop, 6 inches wide, a 3 inch paint brush, a sizing screen, and a piece of oilcloth comprise the outfit. One type of scoop has a 10-mesh screen built into it, the undersized or through 10-mesh material falling into a compartment below; in one corner of this compartment is an opening 1 inch square fitted with a rubber stopper which is removed when the dust is to be poured out. The scoop most frequently used is constructed of 20-gauge galvanized iron and is 6 inches wide and 3¼ inches deep. A telescopic screen box, developed by the Bureau of Mines, is 8-5/8 inches square. The bottom is made of 20-gauge galvanized iron. The inner box is 8 inches square and fits into a groove of the outer box when used as a screen. The inner box is also grooved to allow it to fit into the outer box when closed. The bottom of the inner section is a 10-mesh screen.

When this type of collector is used, it is advisable to start at the roof and brush a 6 inch strip from the roof to the floor. In this method any dust loosened falls on the ledges or projections on the ribs and is recovered as the sampling proceeds towards the bottom. The scoop is light and easily handled and being small is readily thrust into depressions in the ribs or roof. The sides are high enough to prevent the air current from blowing the fine dust from the scoop. As the scoop, brush, and oilcloth fit into the inner box, the outfit is only 8-5/8 inches square and 2 inches deep when ready for carrying. One of the objections frequently expressed is the probability that much of the very fine dust will be blown away when brushed from the rib. When sampling dust in rock-dusted zones, the rock-dust is finer than most of the coal-dust, and the amount by weight actually blown away does not materially affect the results in testing. Moreover, since it is principally rock-dust that is lost to the sample, it tends to lend a factor of safety to the results, as a low incombustible content as shown by analysis of the sample taken will cause the section sampled to be redusted.

Vacuum collectors have been tried in some mines with the object of obtaining all the dust in high velocities of air and to obtain a sample quicker than with the brush and scoop. These results have not been realized as far as is known. Tests made with a certain type of vacuum collector and with the scoop and brush outfit in high, medium, and low air velocities show that the brush on the nozzle of the vacuum collector on the machine used dislodges practically as much dust as the scoop and that the recovery is little if any better than with the

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scoop and brush. The necessity of removing the dust bag, turning it inside out and then brushing the adhering dust into the screen probably causes a greater loss of fine dust in the vacuum method than is found in the standard bureau method. The vacuum process tried also reduces the speed of sampling. If the coal surface is smooth and dry, a sample may be collected rapidly with the vacuum collector; this is true also with the standard method; if the rib is damp, the nozzle on the vacuum collector tends to clog and greatly retards the sampling; on the floor, it is difficult to take a sample without clogging the nozzle of the collector, especially when the dust is thick and must be sampled to a depth of 1 inch.

The recent observations on tests made with a vacuum collector were made with an outfit consisting of a small vacuum cleaner, a 3-foot section of hose, and the ordinary upholstery brushes, in which 8-mesh screens had been placed. At the same time that samples were being collected with the vacuum cleaner, duplicate samples were taken with the standard scoop and brush. The results of volumeter determinations of the dry incombustible matter in the samples are given in Table 2 following:

Table 2.- Determinations of dry incombustible matter in dust samples, as gathered by vacuum-collector and by scoop-and-brush methods.

Sample No.	Velocity of air, cu.ft./min.	Per cent dry incombustible		Kind of dust
		Scoop and brush method	Vacuum collector method	
1	420	87	98	Rib and roof.
2	420	43	47	Road.
3	200	85	84	Rib and roof.
4	200	33	30	Road.
5	(too low to measure)	95	84	Rib and roof. (Road damp.)

It is readily seen that the first four samples check within the limits of error of the volumeter method of making the determinations (the volumeter is accurate to within about 3 per cent, but if samples are from the same mine and determinations are made regularly by the same operator the accuracy should be of the order of 1 per cent). In sample No. 5 the difference is 11; the explanation of this wide variation probably lies in the failure properly to clean the bag of the vacuum collector, so that the fine combustible dust in the preceeding road-dust sample (No. 4) undoubtedly affected the succeeding rib-dust sample.

In collecting sample 1, with the vacuum collector, the nozzle became clogged and it required four minutes longer to take the sample than with the scoop and brush; it required about 9 minutes longer to gather the road-dust sample with the collector than with the scoop and brush. In general it required from four to 10 minutes longer to collect samples with the collector because of the time necessary to connect the mechanism to the source of power and time lost in the clogging of the nozzle, even when the dust appeared dry to visual

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observation. It is interesting to note that in a mine which is apparently dry, the rock-dust on the rib of the chain pillar is usually dry, but the lower part of the rib on the solid or barrier pillar side of an entry, is as a rule damp to moist. This does not prevent sampling with the scoop and brush, but it does greatly retard sampling with the vacuum collector. Frequently the road dust is decidedly damp to moist, even wet, and this condition practically prevents vacuum sampling.

At the present time the scoop and brush method of sampling appears to be a quicker and more convenient method of sampling dust in rock-dusted mines than the vacuum collector as developed to date. The disadvantages of the present vacuum method are: The nozzle clogs easily, due probably to the lack of enough suction by the machine to clear the nozzle of dust, if coarse or damp; the outfit is bulky, heavy, and cumbersome; the necessity of using bare-wire connections makes its use inadvisable from the standpoint of safety and even if this feature is not considered, it is impossible to sample many entries and rooms in which there are no electric power wires.

Identification of samples

The person entrusted with collection of dust samples should carry a notebook and some type of sample identification cards. The sample containers, which should be large enough to hold sufficient dust (about 50 to 60 g.) for making at least two determinations with a volumeter, should be distinctly marked with a number or with similar means of identification. The number of the sample can, the date, the name of the collector, the point at which the sample was taken, the kind of dust (rib and roof, timber, road etc.), and remarks as to special conditions, such as wet, moist, dry, road recently cleaned, and similar information should be entered in the notebook. The sample identification card should also contain the number of the sample can, the date, the name of the collector, the location at which the sample was taken, and the kind of dust. The card is then placed in the container. When the sample is opened in the laboratory or wherever the samples are to be analyzed, the information on the identification card should be compared with the record in the notebook, and the container number should be compared with the number on the card. These precautions will prevent samples from becoming mixed.

Recording data

Permanent records should be kept of all dust samples and the percentages of incombustible matter in them. It is recommended that a book be provided in which such a record can be kept. The information in the notebook should be transferred to the permanent record book, and the volumeter determinations or chemical or other analyses should also be placed in the book. Many of the more progressive coal companies keep up to date a map at the mine and in the office of the safety director showing the extent of the rock-dusting and the percentage of dry incombustible matter at each point from which a sample has been taken. Moreover, as

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soon as the samples are analyzed, the results are typed and the report sent to the mine superintendent and to the general superintendent or safety director. This system is highly commendable and should be used at every mine where rock-dusting is done.

Conclusions

Rock-dusting is recommended not only because it renders the coal-dust inert to explosibility but also because the noncombustible condition does not change rapidly in character, as is the case with water; but to obtain the full benefit of this explosion-prevention method the dust must be sampled periodically preferably monthly, to give a check on the average condition of the rock-dust. The periodical samples should be collected from at least one representative point in zones not over 1,000 feet long, on all entries, and in rooms. The road-dust should be sampled separately from the rib and roof dust or timber dust. The dust should represent average conditions and should not be vitiated by unusual conditions. The scoop and brush method used by the Bureau of Mines for collecting samples is recommended, but any method that will obtain representative samples may be employed. All samples should be properly identified, so that after determinations are made, the results can be entered as a permanent record; copies of the results should also be sent to the mine superintendent, the general superintendent, and to the safety director. If these precautions are taken to insure the proper incombustible content of the mine dusts, and if rock-dusting is carried out as recommended by the Bureau of Mines, all coal mines should be immune from extended coal-dust explosions.

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